

A Close Look at Broward's Coastal Ocean:

The Broward County Coastal Monitoring Program

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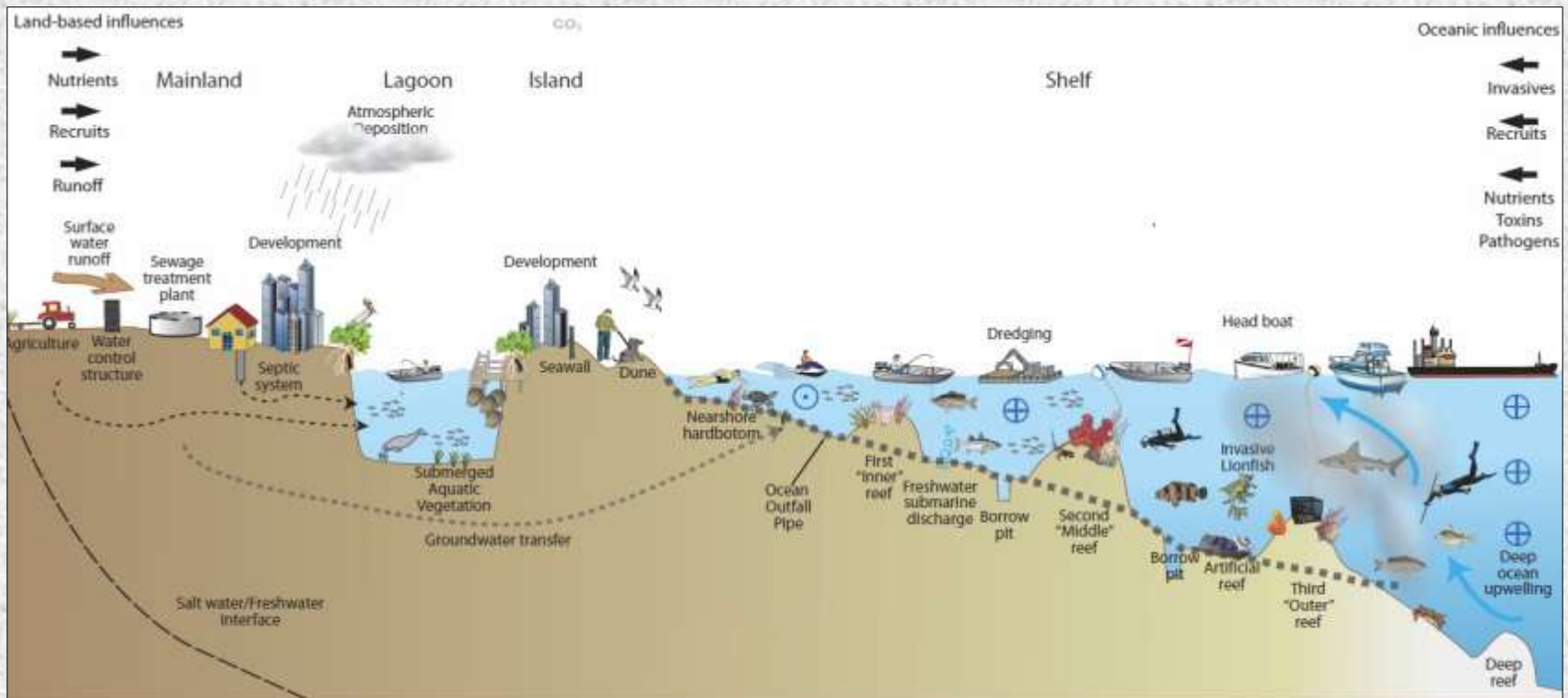
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NOAA Atlantic Oceanographic and Meteorological Laboratory

**Broward County Water Advisory Board Meeting
Broward Government Center
Fort Lauderdale, Florida
January 16, 2014**



Maintaining Healthy Coasts: Assessing Anthropogenic Inputs



MARES SEFL ICEM

Point sources: Inlets, wastewater treatment plant (WWTP) outfalls.

Non-Point sources: ground water, atmospheric deposition, city runoff

“Nutrients” (nitrite, nitrate, ammonium, phosphate silicate), pathogens, organics.

Goal: maintain low nutrient concentrations in Florida’s coastal waters:
“Oligotrophic” conditions

The Broward County coastal monitoring Program

- Chemical measurements near WWTP outfalls, inlets, and 'background' regions.
- Ocean currents by Doppler acoustic technology
- Microbiology of human pathogens



Br: 18 stations



HW: 15 stations

Measurements obtained (3 depths)

- salinity
- water temp.
- O₂ saturation
- pH
- turbidity
- nitrite NO₂⁻
- nitrate NO₃⁻
- ammonium NH₄⁺
- orthophosphate
- silicate
- chlorophyll-a
- phaeopigments
- total suspended solids (TSS)
- total dissolved N
- total dissolved P
- total particulate P
- total particulate N
- dissolved organic C
- Enterococci
- *Giardia* & *Cryptosporidium*
- source tracking
- bacterial DNA sequencing

24 oceanographic cruises from Nov 2010 through Jan 2012

NOAA research ships used in the study



The R/V Cable

21' length, 8'6" beam, draft 15".

Diver support. Down-looking ADCP.



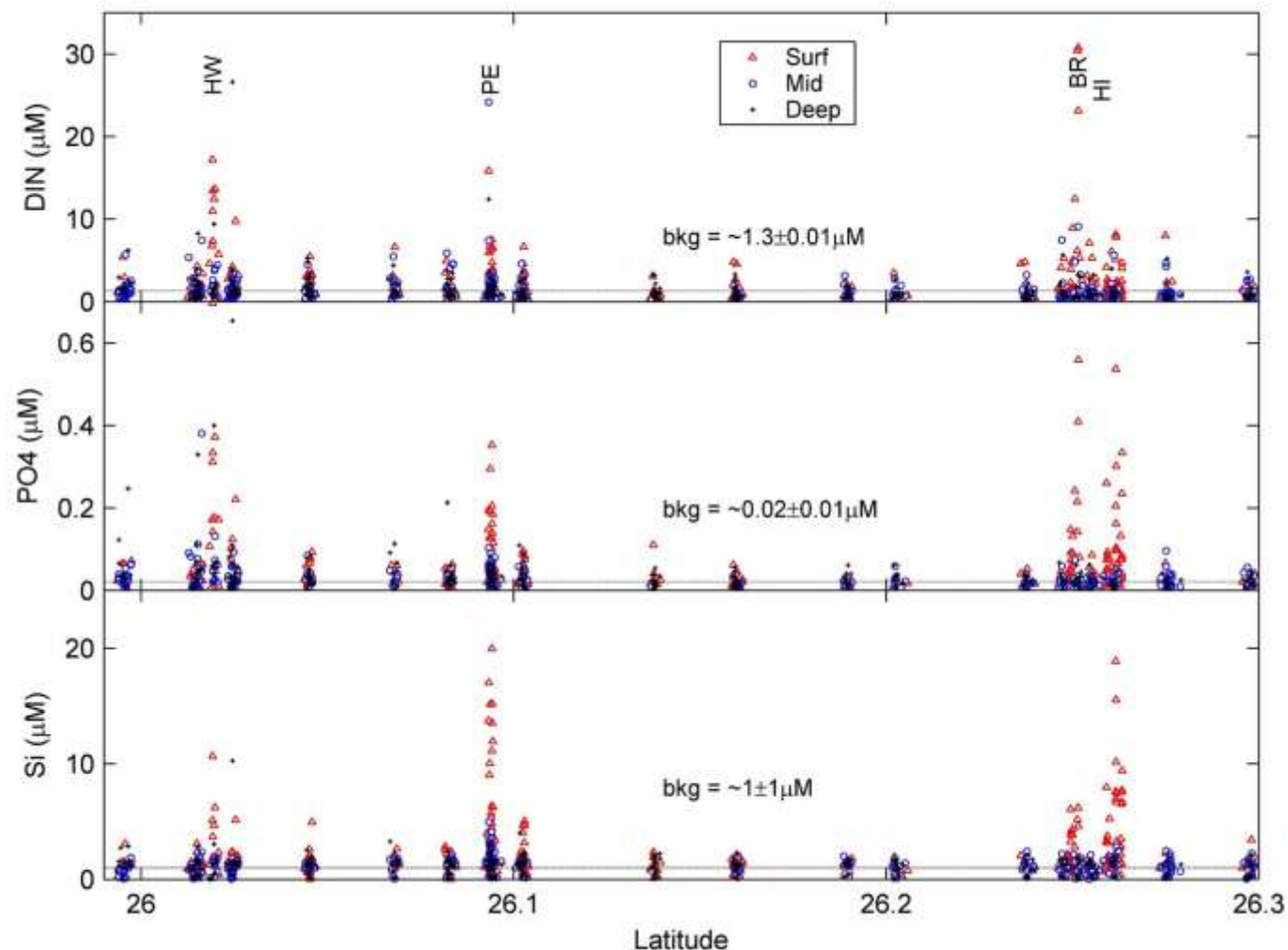
The R/V Hildebrand.

41' former USCG UTB with an A-frame, a winch and a Seabird ECO 55 rosette sampler holding six 4-L seawater sampling bottles.



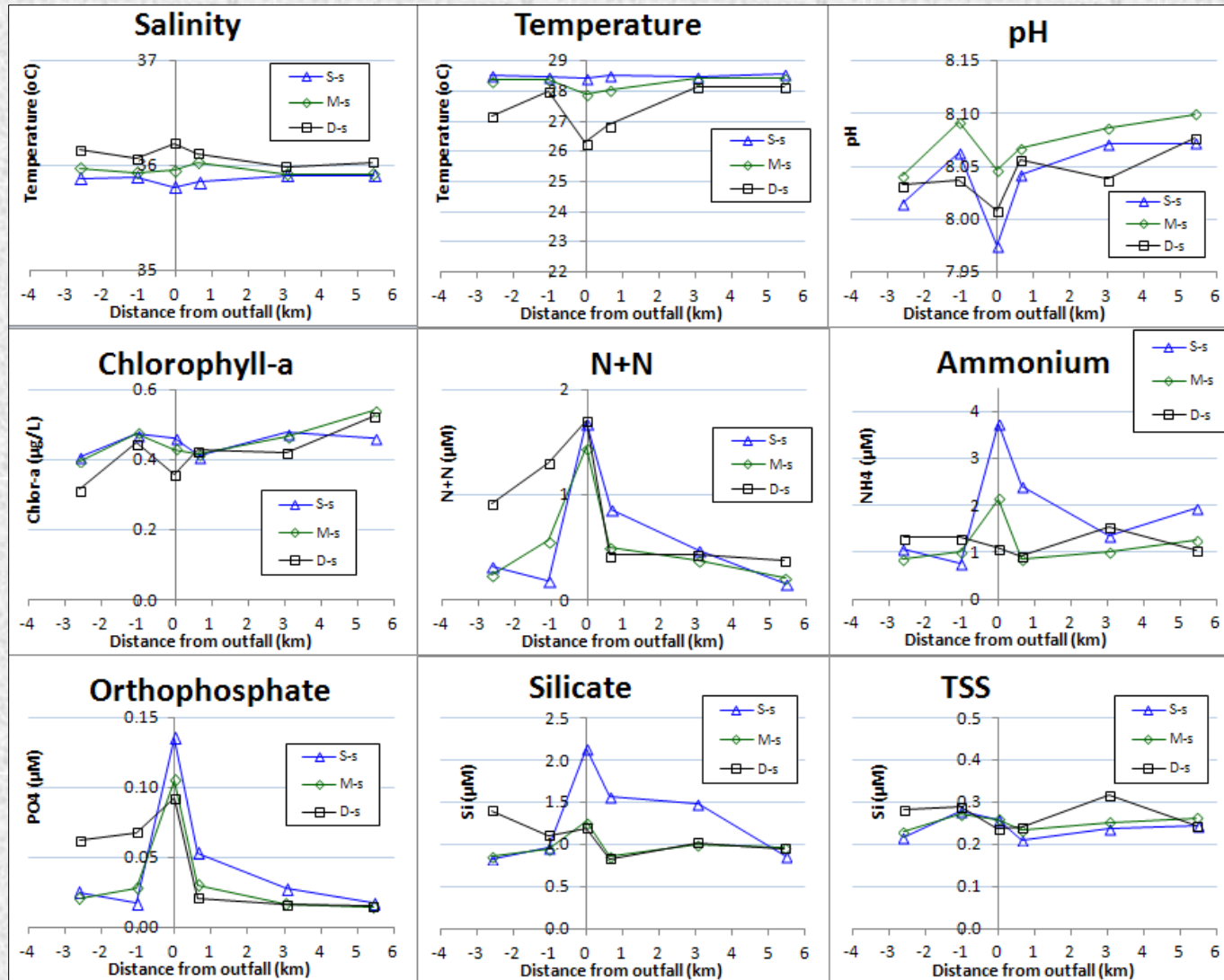
Rachel Kotkowski and Chuck Featherstone operating the CTD (conductivity-temperature-depth).

Overview of Results: Nutrients



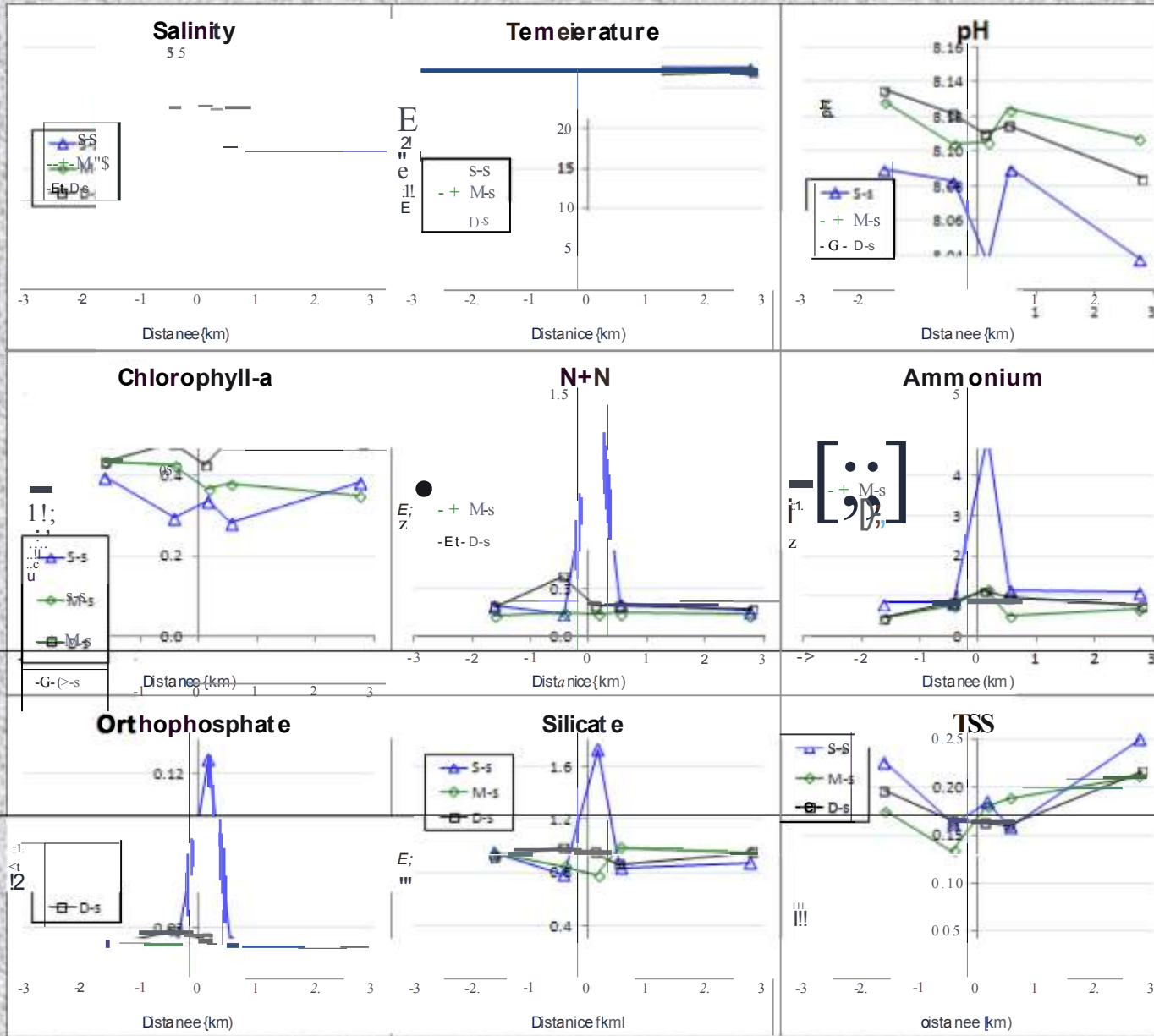
Pattern: low “background” concentrations of nutrients
With elevated values around point sources (inlets, outfalls)

Points Sources: Hollywood WWTP outfall plume



Concentrations (at 3 depths) averaged over year separated (summer values only).
 Outfall was not a source of chlorophyll-a, TSS or turbidity. Plume disappeared after ~1km.

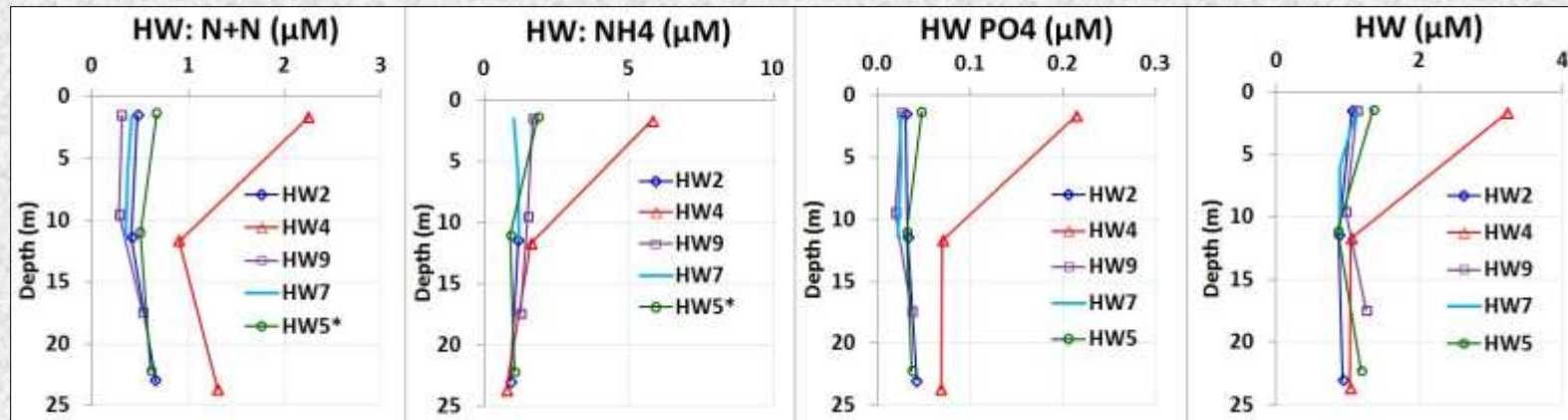
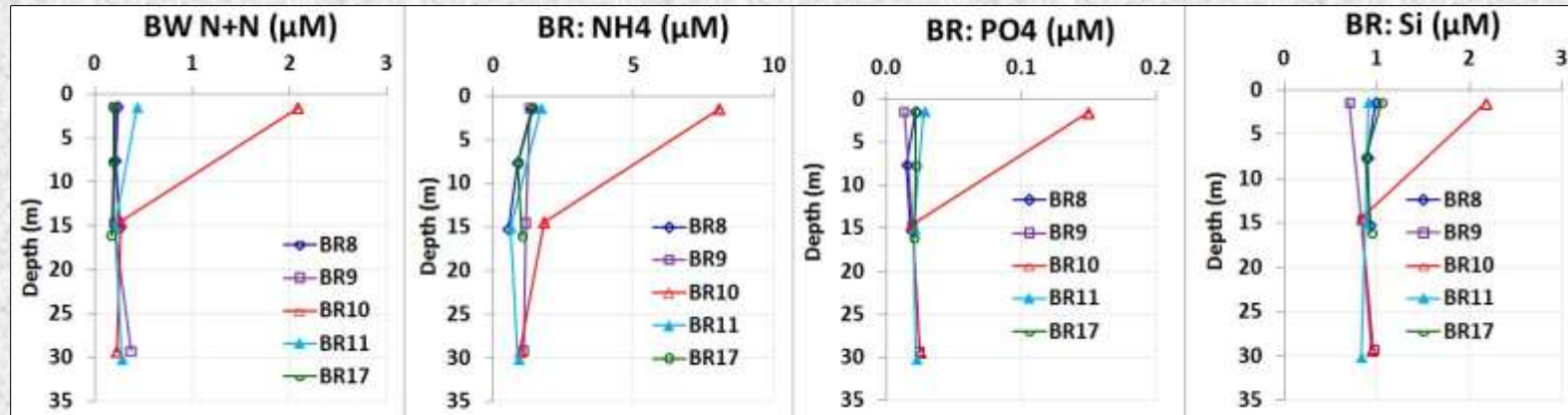
Points Sources: Broward WWTP outfall plume



Similar to the HW outfall (summer data only). Plume disappeared by ~1km.

WWTP Plumes: Concentration vs. Depth

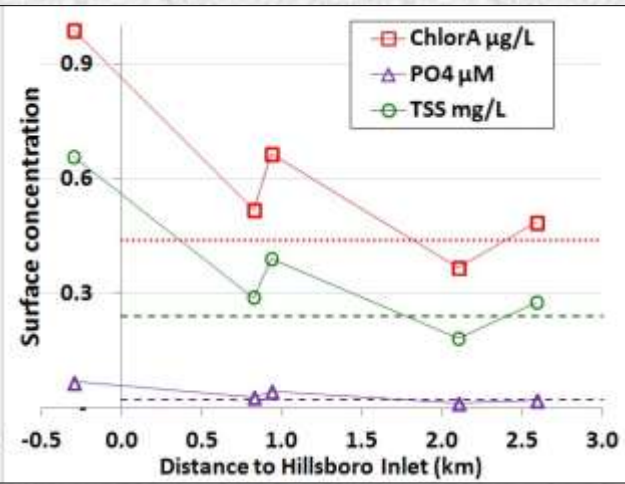
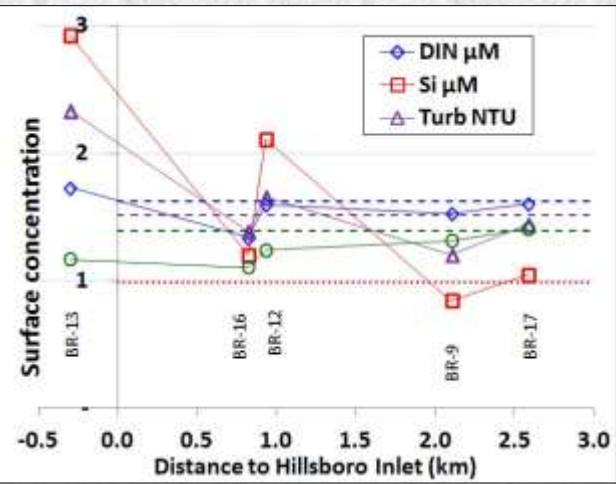
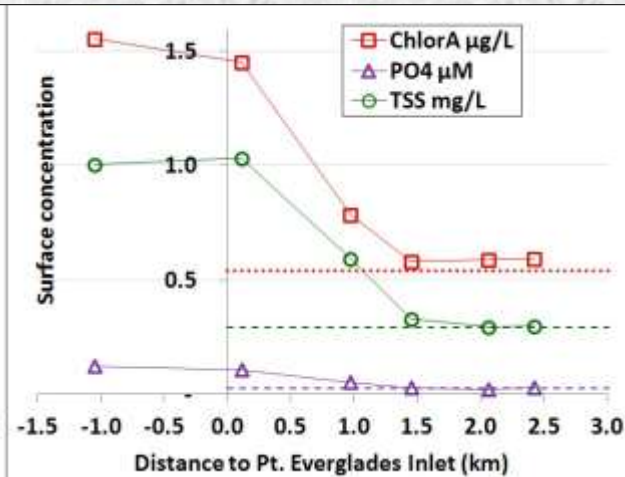
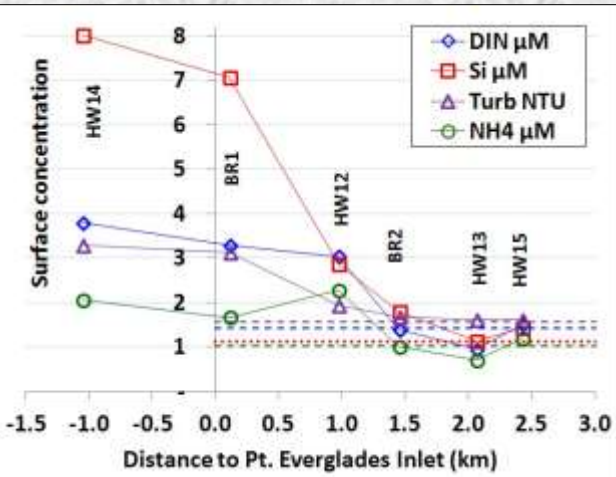
Does the plume move downward?



Red line: outfall sample site.

No unequivocal evidence for downward movement of plume.

Point Sources: Pt. Everglades and Hillsboro Inlet Plumes



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Tracking Outfall Plumes: BR tracer Exp.#1, 7-Nov-2012



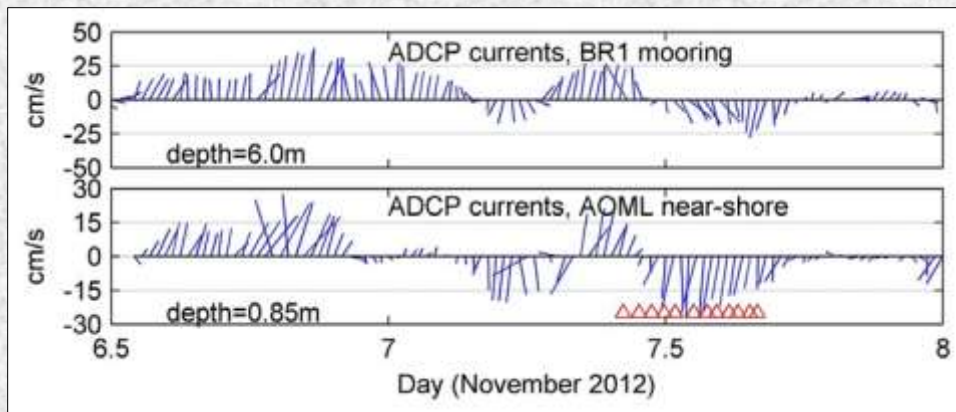
Dye plume from R/V Hildebrand.



Name	Latitude	Longitude	Depth (m)
M1	26.25570°	80.06171°	1.34
M2	26.26025°	80.06145°	1.25
M3	26.26036°	80.06667°	14.03

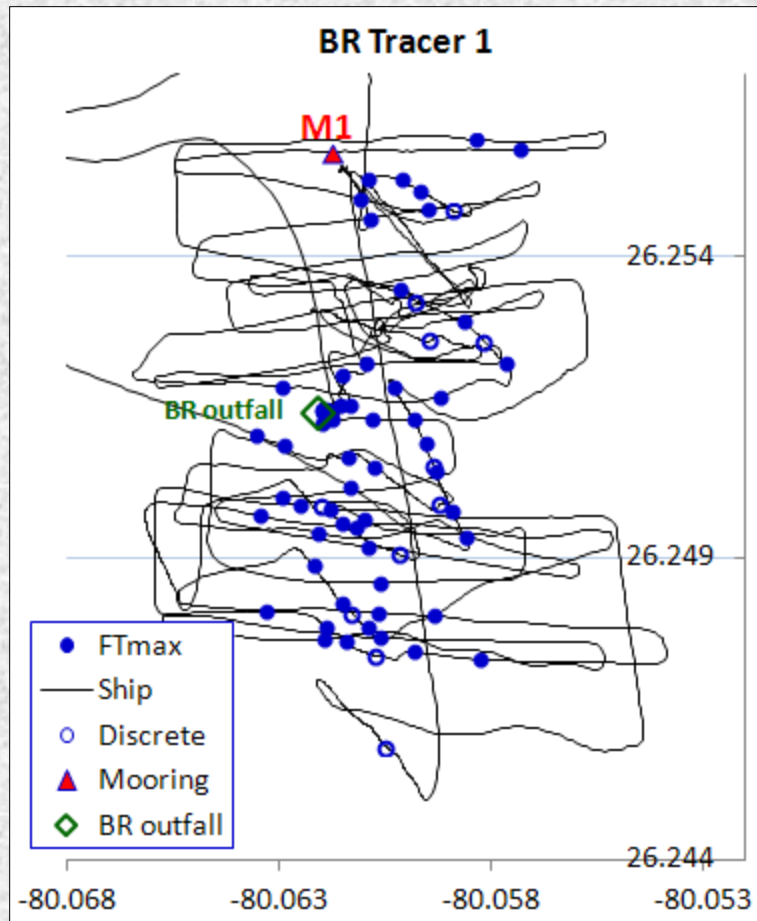
No dye seen at M2 or M3. M1 observed RD plume near the beginning of the experiment only (from N current flow).

Pipe to boil dilution = ~110



Currents N (early), then S.

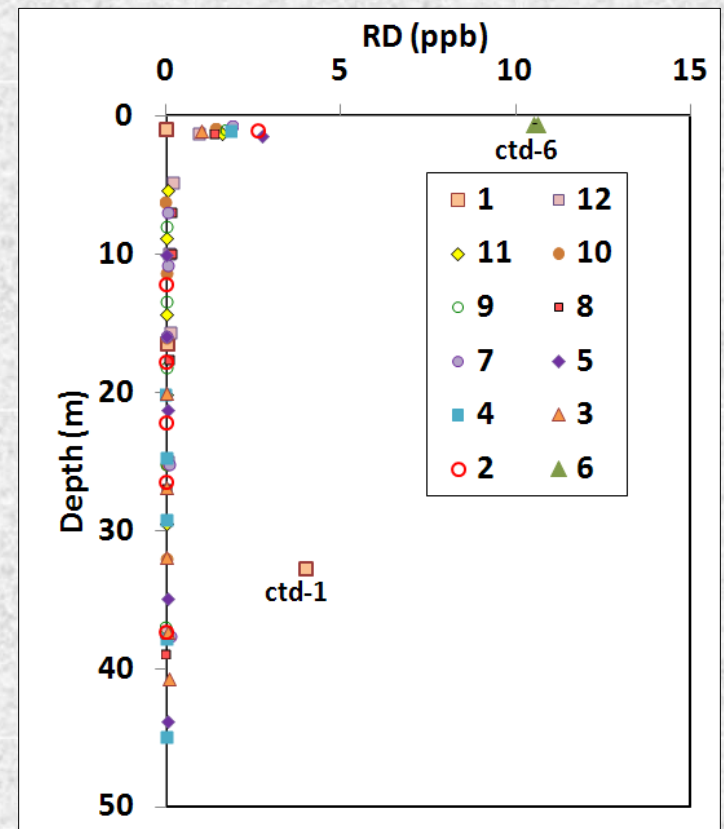
BR-1 Tracer: CTD and ship flow-through data



Moored sites 2 and 3 at the wrong locations!

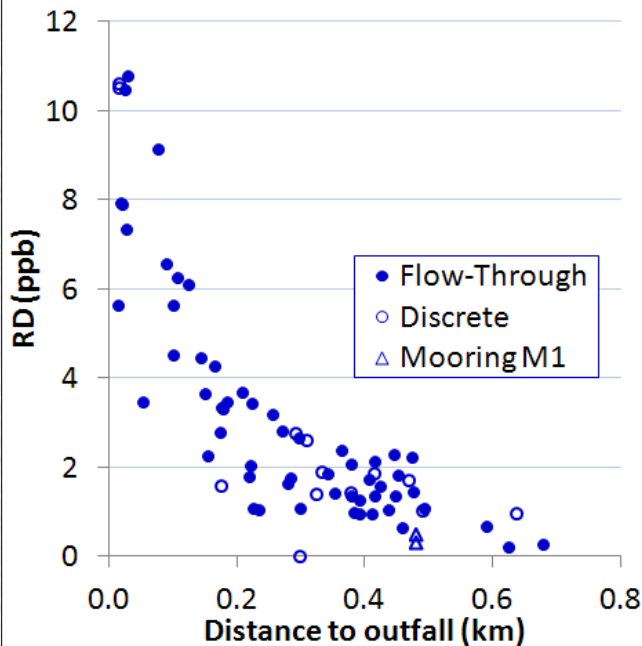
However, ship tracked plume and obtained CTD and flow-through data. Left, ship track with flow-through and CTD bottle maxima.

With one exception, no RD was found at depth away from the outfall. Most of the plume confined to the surface.

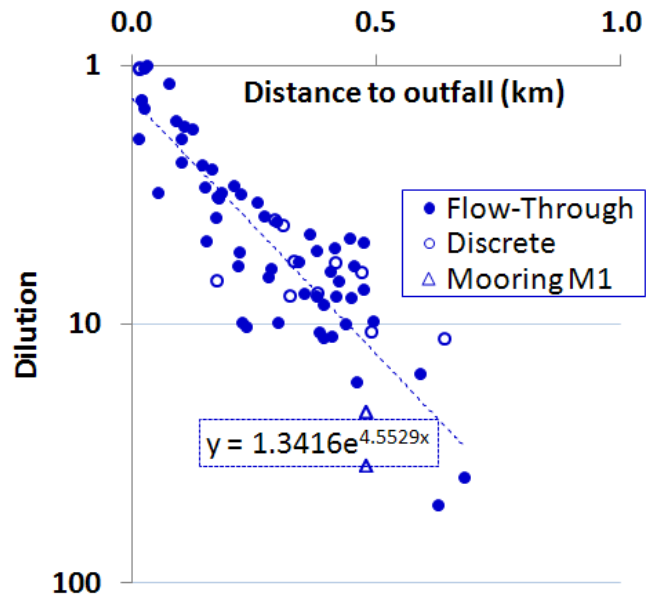


BR1 Tracer: plume characteristics

RD conc. versus distance

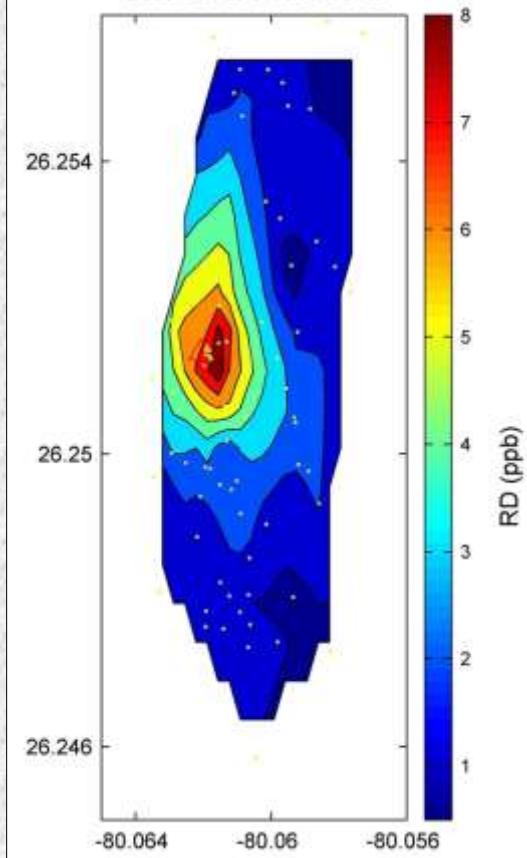


Dilution versus distance



There is general agreement within the three data sets, showing an exponential dilution with distance. The dilution with distance was much higher than what was measured at HW. A distinct near-field dilution was not evident.

BR1 tracer 7-Nov-2012



Contour plot of all of the surface RD concentrations.

MEASURING OCEAN CURRENTS:

Acoustic Doppler Current Profiler (ADCP) installations

Current data (velocity & direction) from four ADCPs were used in this study.

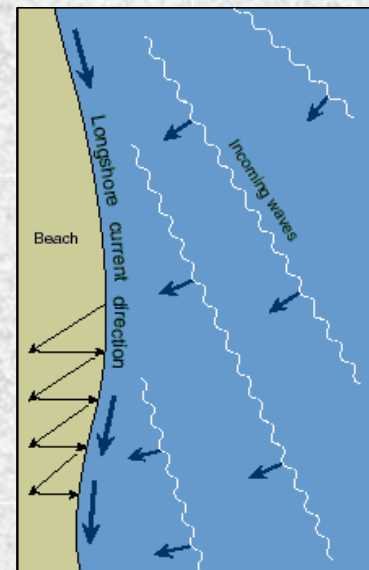
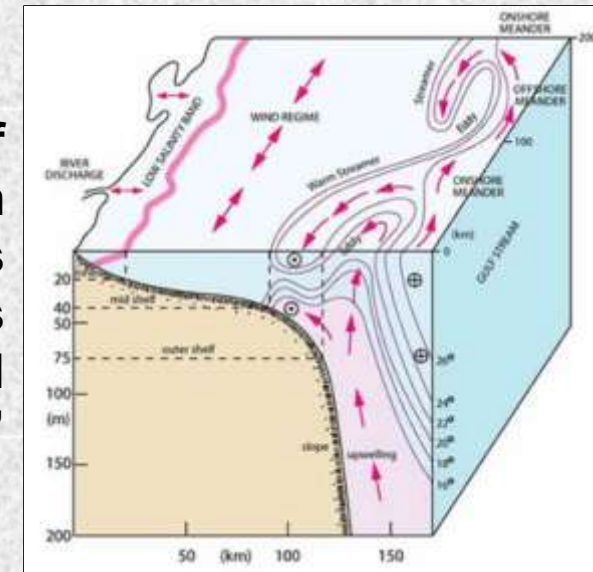


**Nearshore BR
ADCP**



**Nearshore HW
ADCP**

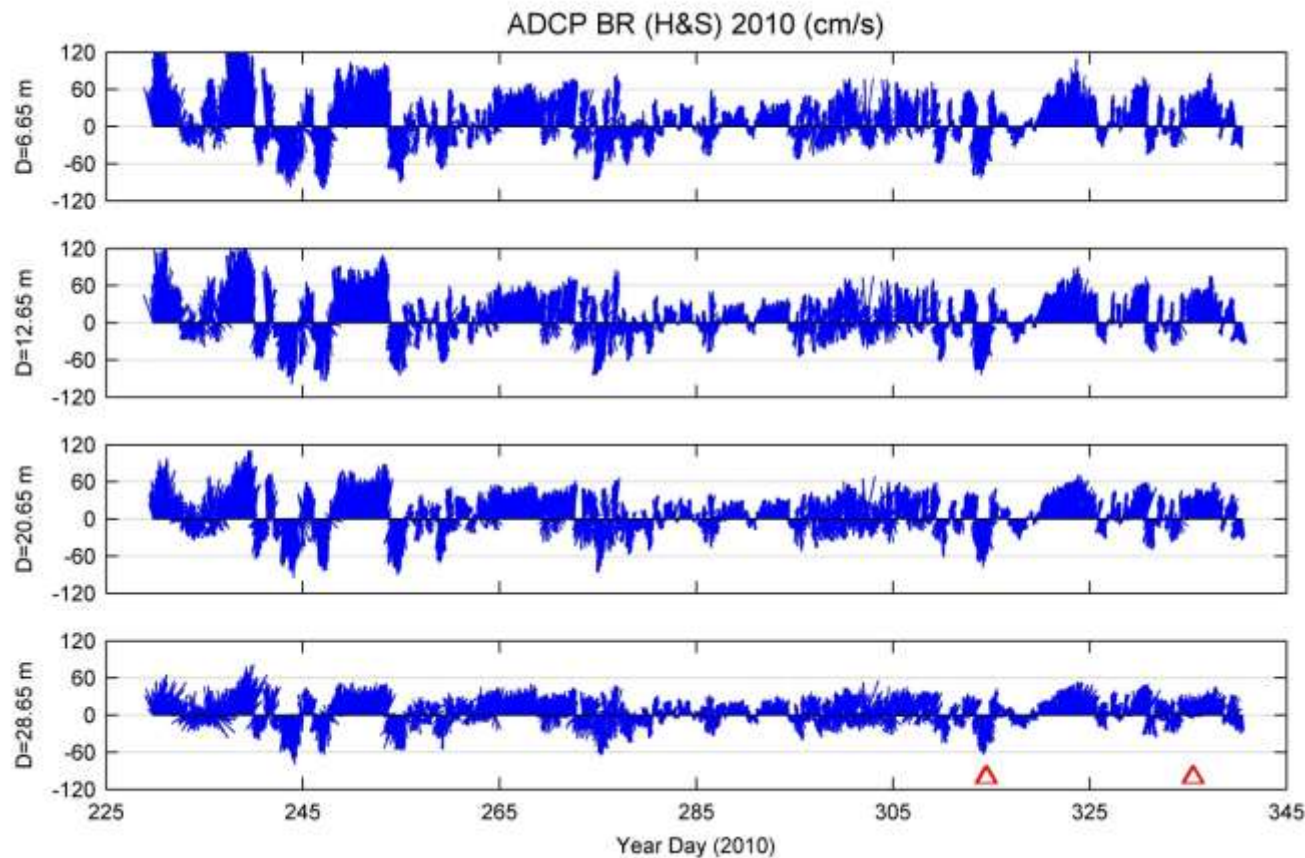
**Gulf
Stream
meanders
eddies
and
“seiches”**



**Longshore
currents**

And: ADCPs at the HW and BR outfall (H&S)

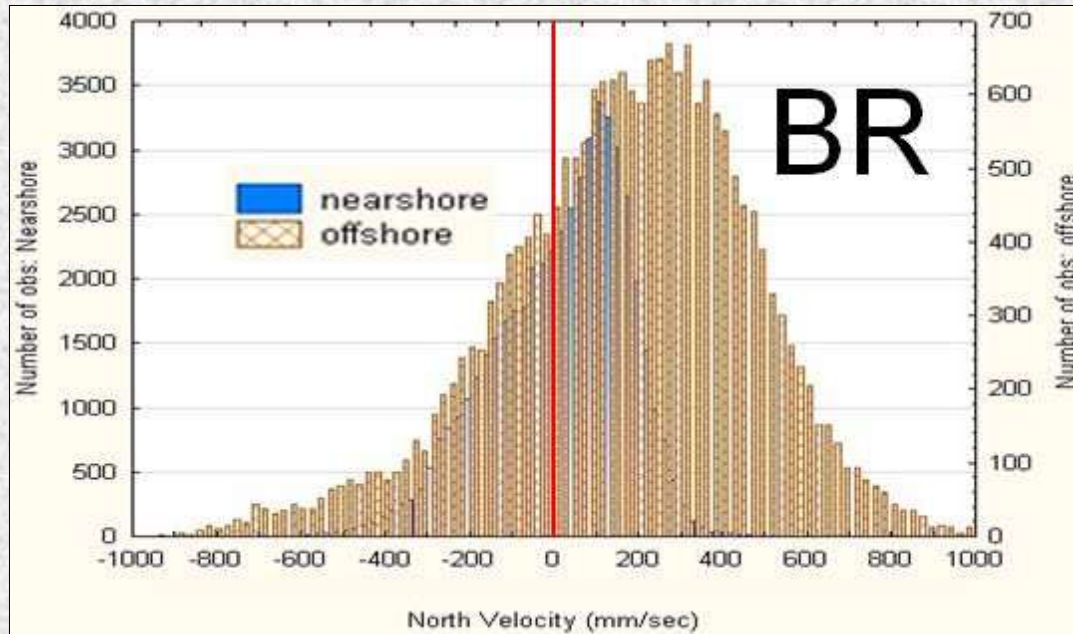
An example of ADCP results: Rapid shifts between N and S flow



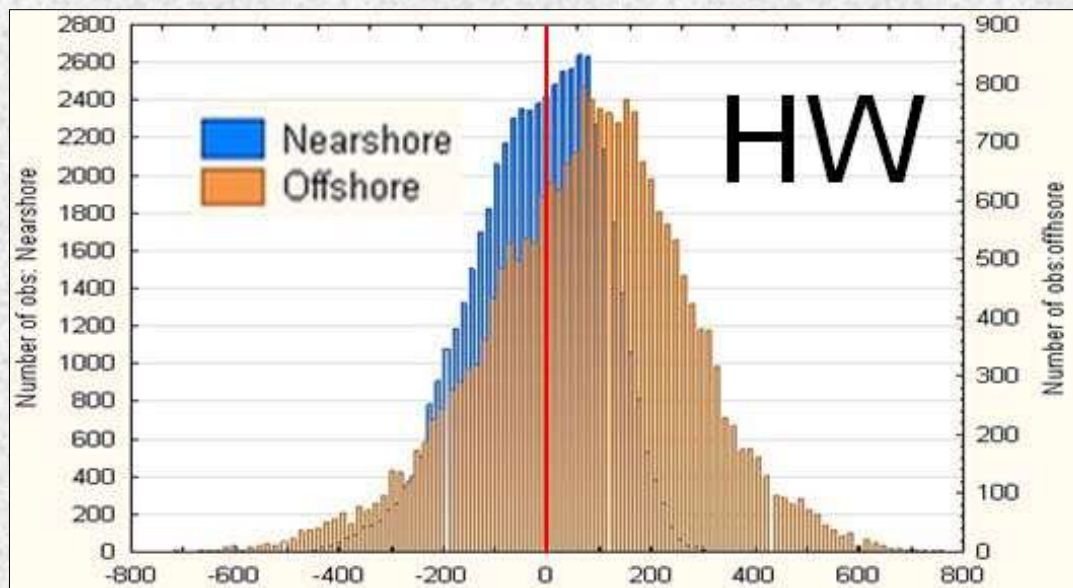
Data from BR ADCP
(32 m depth).

Stick plots for near-surface (upper) to bottom (lower) bins from the BR ADCP located at the outfall (H&S). Currents are similar through depth, with velocity decreasing with depth.

Comparing Nearshore & Offshore currents



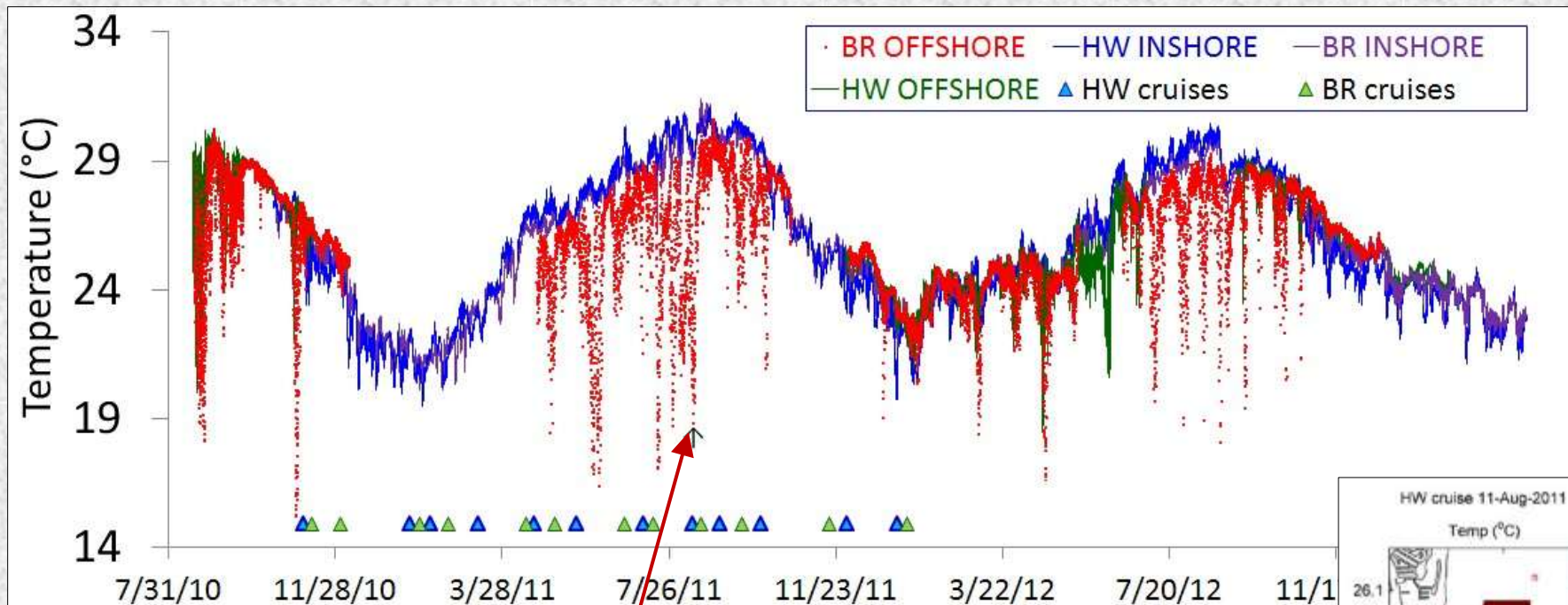
The nearshore ADCPs saw substantially more S-flowing current. At the HW nearshore ADCP, the current was S >50% of the time!



%S flow at the four instruments

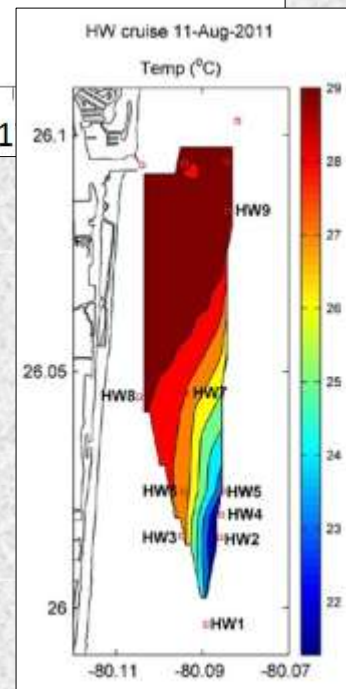
<u>BRns</u>	<u>BRof</u>	<u>HWns</u>	<u>HWof</u>
40.2	27.1	51.7	33.7.

Upwelling from the Gulf Stream: An event observed on 11-Aug-2011



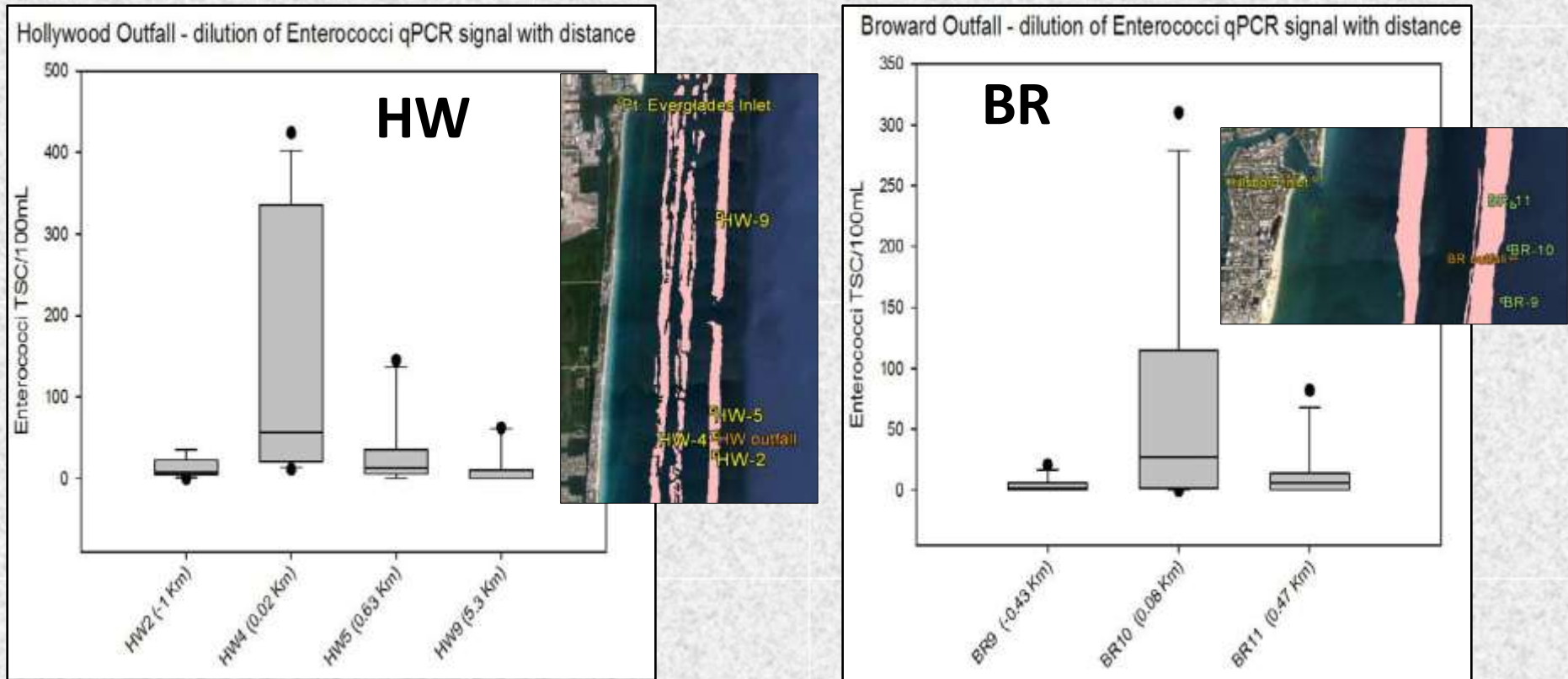
11-Aug-2011: Nearly 10°C drop in HW2,4 associated with elevated NO₃ values: indications of upwelling.

Contour plot of CTD temperatures



Broward County coastal waters: Microbiology

Total Enterococci by qPCR vs Distance from outfalls



Boxplots of all cumulative monthly cruise data showing the decrease in abundance with distance from the outfall for total Enterococci (dead, dormant, and live) as measured by the Entero1A qPCR assay at the Hollywood outfall (right) and Broward outfall (left).

Summary: Chemical Oceanography

• *The water column appeared to support ecosystem health.* Concentrations of TSS and turbidity were low over the reef tracts, indicative of sufficient water clarity. Dissolved oxygen levels were always sufficient to support marine life (>80% of saturation) at all depths. Chlorophyll-a concentrations exceeded phaeopigments (averaged ratio was 3.5, and always exceeding unity), an indication of non-bloom conditions.

• *Inlets were an important source of nutrients* and chlorophyll-a, and contained the highest concentration of chlorophyll-a, phaeopigments, turbidity, and TSS. However, excess concentrations were *not observed at distances >~1.5 km* downcurrent from the inlets in the surface ocean.

• *The two ocean outfalls were a significant source of nutrients;* primarily observed in surface samples. Nutrients *decreased to coastal background values usually within ~1 km.* The outfalls were not a significant source of excess chlorophyll-a, turbidity, TSS, or reduced or elevated pH.

• *No unequivocal evidence of downward movement* of nutrients from outfall plumes was observed.

Summary: Ocean Currents

- Currents in the vicinity of both outfalls, while *predominantly northerly* (Gulf Stream), are characterized by frequent, generally counterclockwise reversals.
- A *south-flowing coastal current* is an important feature of the coastal water column. The percent of southward-flowing water increases as one goes inshore.
- ADCP temperature data suggested that *upwelling occurred frequently*. A 6-day episode on 11-Aug-2011 was fortuitously sampled during one of the monthly cruises; an excess (above 'background' concentration) $\sim 4.2 \mu\text{M}$ nitrate was found at 21 m depth (3rd reef track).

SUMMARY: MICROBIOLOGY

- ***Elevated concentrations of fecal indicator bacteria*** and human-specific microbial source tracking markers were associated with inlets and outfalls and were primarily confined to surface samples and most commonly decreased to relative background levels within 1-2 km of the discharge source, with a large decrease in abundance within the first 0.2 km.
- ***Low concentrations of viable enterococci*** were found in coastal waters. Concentrations were highest near inlets and outfalls, but diluted rapidly to near detection limits within 1 km.
- ***No significant levels of pathogenic protozoan (oo)cysts were observed*** in the surface expression boils of either the Hollywood or Broward outfalls for samples collected during this study, but for one exception.
- ***Specific human and coral bacterial pathogens in both Inlet and Outfall discharges*** were identified by community DNA sequencing. Most of the Outfall bacterial pathogens are presumed dead or dormant from treatment, based on viable fecal indicator tests, while Inlet pathogens are presumed potentially infectious.

Thanks to our many co-workers and collaborators

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Chris Kowalewski	NOAA	Richard Kowalewski	NOAA/CIPO
Jack Hamilton	NOAA	John Pisoni	NOAA/CIPO
William DeSoto	NOAA		



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Report: Broward County Coastal Ocean Water Quality Study 2010-2012.
NOAA Technical Report OAR-AOML-44, 2013.

<http://www.aoml.noaa.gov/themes/CoastalRegional/projects/FACE/faceweb.htm>

